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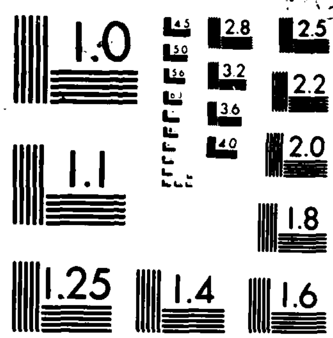

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AIR WAR COLLEGE

RESEARCH REPORT

No. AU-AWC-86-108

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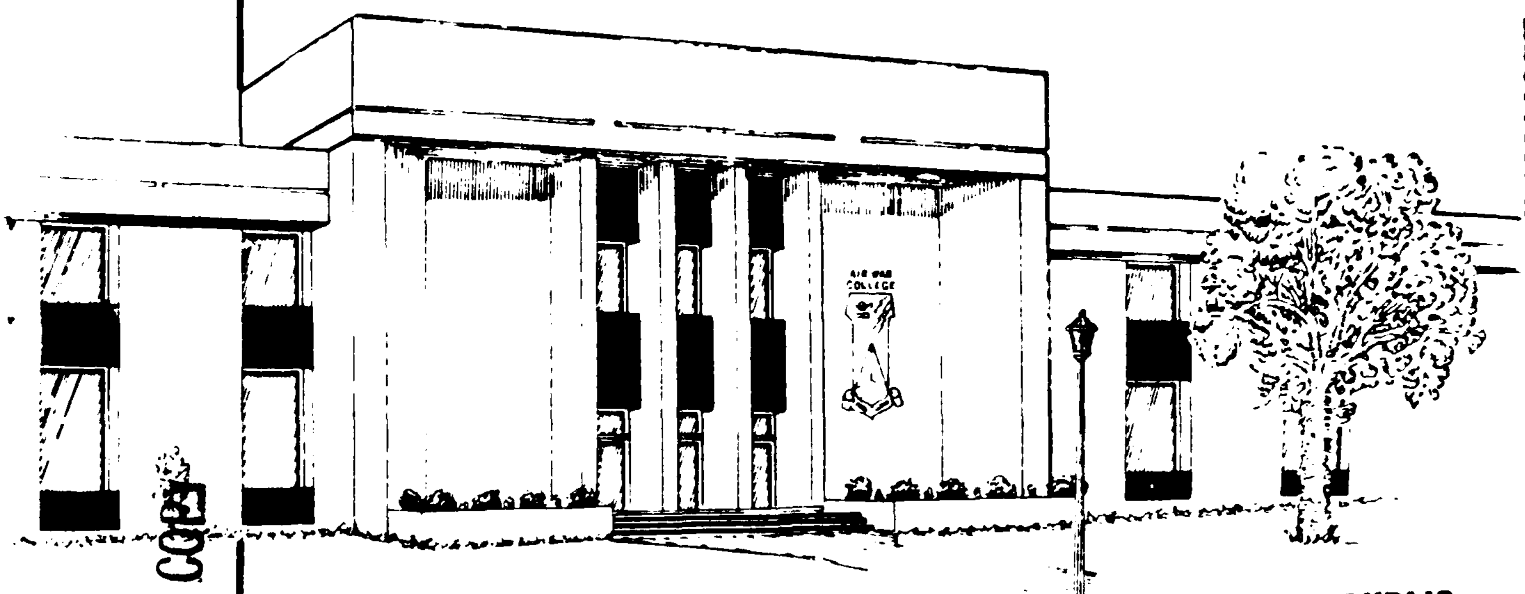
AN INDICTMENT--A SOLUTION

By LT COL STEVEN G. JOSEPH



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UNITED STATES AIR FORCE
MAXWELL AIR FORCE BASE, ALABAMA

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AUTOMATED AIRCREW SCHEDULING WITHIN THE STRATEGIC AIR COMMAND: AN INDICTMENT--A SOLUTION

by

Steven G. Joseph
Lieutenant Colonel, USAF

A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisor: Lieutenant Colonel Robert F. Fowler

MAXWELL AIR FORCE BASE, ALABAMA

May 1986

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: Automated Aircrew Scheduling Within the Strategic Air Command: An Indictment — A Solution

AUTHOR: Steven G. Joseph, Lieutenant Colonel, USAF

The potential for increasing the effectiveness of aircrew training within the Strategic Air Command through more effective scheduling is reviewed, and a case is made that automated assistance is required to achieve any significant improvements. Following an exploration of the failure of the Strategic Air Command to develop such a capability, guidelines for future development efforts are offered. A description of the Scheduling Assistance System developed during the research as a feasibility demonstration model for automated aircrew scheduling is presented. The author concludes that an automated scheduling system is both necessary and feasible.

BIOGRAPHICAL SKETCH

Lieutenant Colonel Steven G. Joseph has been closely associated with aircrew training since his assignment as an Air Training Command (ATC) instructor pilot in 1972. Upon graduation from the University of Michigan with a master's degree in mathematics, he was assigned as a computer systems design engineer at Headquarters, United States Strike Command, before attending undergraduate pilot training in 1971. After his instructor pilot tour, he served for three years as an operations research analyst at ATC headquarters, where his study Alternatives for Future Undergraduate Pilot Training initiated current ATC efforts towards specialized pilot training. After serving as a B-52 aircraft commander for a year, he became the Director of Training at Fairchild AFB where he first began to apply computer technology to the aircrew scheduling problem. Subsequently assigned to Strategic Air Command headquarters he developed several tools to analyze the command's aircrew training program. Colonel Joseph is a distinguished graduate of the Air Command and Staff College and a graduate of the Air War College, class of 1986.

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CHAPTER I

INTRODUCTION

The concept of automating various aspects of the aircrew scheduling process has existed within the Strategic Air Command (SAC) for well over a decade. In a 1974 report the idea was expressed by:

> The need to move rapidly through a series of schedules implies a heavy computational load that can best be met by computers. However, the nature of the decision environment with its large and complex interrelated set of objectives requires a man to direct the schedule building activity. This man-machine system, with weights on objective elements which can be varied as their effects on schedules become apparent, implies that anything short of on-line interactive computing will be insufficient.[1]

Later, in September 1979, the vice commander in chief of SAC directed the deputy chiefs of staff for Operations (DO) and Data Services (AD) to investigate the feasibility of applying commercial airline automation concepts to the aircrew scheduling problem within SAC.[2] By January 1980, Data Automation Requirement (DAR) A80-04, EC-135 Feasibility Study (later changed to Crew Scheduling System) was produced to develop a prototype aircrew scheduling system which would serve to test and define concepts for eventual command-wide application.[3] This DAR marked the initiation of the most recent efforts to apply automation to the scheduling process within SAC. In March of that year, the SAC chief of staff approved the project.[4]

Meanwhile, with the advent of the personal computer, field units also recognized that various functions could and should be automated, bombarding HQ SAC with numerous requests for microcomputers to develop their own tools and solutions to the problems which they were encountering.[5] (Most of these requests were turned down at the HQ level under the pretext that such local efforts would only duplicate HQ SAC efforts and would therefore be unnecessary.)[6]

With all this effort, why is it that, as of March 1986, not a single piece of hardware or software has been fielded under the aegis of automated aircrew scheduling? Why has the project failed so miserably? Is it a valid requirement? Is there a solution and, if so, what is it?

This report attempts to answer these questions by first identifying the need for an automated aircrew scheduling system. It then examines the reasons for the failure of the current efforts to produce anything useable, and provides guidelines for further efforts.

However, the primary thrust of this research project has been the development of the Scheduling Assistance System (SAS), a comprehensive set of computer programs for the automated generation and evaluation of aircrew training schedules. Chapter V describes the capabilities of SAS in some detail, while comprehensive User's Guides are provided under separate cover.

CHAPTER II

WHY AUTOMATED SCHEDULING ASSISTANCE?

The primary function of scheduling in a typical SAC wing is to provide trained, mission ready crews, capable of fulfilling their wartime tasking. More specifically, schedulers are charged with the responsibility of ensuring that all training requirements for aircrews and aircrew members are scheduled so as to satisfy the minimum requirements established in the applicable SAC 51-series regulations.[1] These regulations specify the minimum volume and frequency of accomplishment of numerous training events known as command directed events (CDEs) as well as unit unique events called wing directed events (WDEs).

This is generally accomplished by the development of quarterly training plans which are further refined to monthly operations plans (MOPs) and finally to weekly flying schedules. Training missions or sorties are developed and distributed among crews in an attempt to satisfy the training requirements. Of necessity, sorties are interspersed among periods of ground alert, combat crew rest and recuperation (CCRR) following alert, leaves and TDY. Ground training requirements, such as simulators, life support training, flight physicals, physiological training, etc. must also be worked into the schedule. In short, the scheduler's function is to match resources with requirements.

Training Accomplishment

During 1984 and 1985 the Training Management Information Branch, HQ SAC/DOTFT, produced a set of exhaustive Aircrew Training Reports (ATRs) which examined B-52, KC-135 and FB-111 aircrew continuation training.[2] Each flying training event was examined in considerable detail. One particular measure, the individual completion rate (ICR), is especially pertinent. The ICR of a particular CDE is the percentage of crew members who have satisfied the minimum currency and volume requirements of the applicable SAC 51-series regulation. For example: If the requirement for sorties is ten per quarter, and all crew members achieve nine, the ICR is zero since not a single crew member satisfied the minimum requirement. The ICR for a frequency event was computed by examining the percentage of crew members who were overdue or delinquent on the last day of the training period.

TABLE I

PERCENT OF TRAINING ITEMS WITH ICR BELOW 85

ACFT	3/84	4/84	1/85	2/85
B-52	59.8	57.6	48.9	43.3
KC-135	19.0	20.3	24.6	23.2
FB-111	17.0	15.1	11.3	3.8

NOTE 1: Only mission qualified crew members included.

NOTE 2: Contingency training events not included.

An ICR below 85 was used by HQ SAC/DOT for purposes of identifying potential problem areas. The preceding table depicts the percentage of CDEs which fell into the problem category for a one year cycle. As is readily evident, B-52 aircrews experience significant difficulty in achieving satisfactory training rates. This factor has import later in this report. There are several reasons which contribute to the low B-52 ICRs. These include:

- low sortie production rates
- poor distribution of scheduled activity
- aircraft modification and conversion programs
- insufficient training opportunity
- higher headquarters directed (HHD) exercises
- crew member inattention to 51-series requirements

While unit schedulers have little or no control over several of these factors, sortie distribution and training opportunity are specific responsibilities. It is also the scheduler's responsibility to mitigate the adverse impacts of external influences.

Although several CDEs were identified as having low ICRs command-wide, the ICRs for the same event varied greatly among individual units. This tends to confirm the idea that different units have better schedulers. It also suggests that improved scheduling practices, even manual, can result in improved training rates, especially among those units on the lower end of the spectrum.[3]

Another way of looking at these low training rates is to consider the lost opportunity costs of maldistributed training. To achieve a 1 percent improvement would require roughly a 1 percent increase in flying hours and sorties. If the same improvement can be achieved through better scheduling, the net result, with B-52 annual flying hour costs in excess of 800 million dollars, is an annual productivity enhancement worth eight million dollars.[4] One study has suggested that a 7 to 10 percent improvement is realistic.[5] To this point, an argument has been made that B-52 units are not achieving satisfactory training rates, that improvements can be made, and that the lack of improved scheduling is costly, yet these factors alone do not dictate an automated solution.

Turning to the computational aspects of the scheduling problem, consider the number of data elements which need to be examined in a typical B-52 unit. For this compilation an OAS/ALCM equipped B-52 unit with 21 authorized crews and no contingency taskings is used. Only command directed flying training events for mission qualified (line) crews and crew members are considered. The table below, based on SACR 51-52 requirements, depicts the type and number of data elements which must be considered by the scheduler, but is by no means a complete listing.[6]

TABLE II

SCHEDULING DATA ELEMENTS

*Number of events required	237
*Number of events accomplished/remaining	237
Number of times scheduled	237
*Date last accomplished	43
*Date due	43
Date next scheduled	237
Attrition factor (loss rate) per event	86
	1120
Times 21 crews	x 21
Total	23520

* Item tracked by AFORMS

Add to this total unit requirements, ground training requirements, alert, leave, flight physicals, HHD taskings, DNIF/DNIA, staff flying, upgrade training, etc., and the number of individual data elements to manage, examine, analyze and weigh far exceeds the capabilities of manual data management.[7]

Some automated assistance is provided by the Air Force Operations Resource Management System (AFORMS). This on-line system tracks training accomplishments and identifies training remaining. Essentially a bookkeeping system, AFORMS has no capability to generate a schedule or, for that matter, to evaluate the effectiveness of a manually produced schedule.

It is specifically in the area of schedule generation and evaluation that an automated capability is needed, a need identified as early as 1974, and regularly reaffirmed by unit schedulers.

CHAPTER III

WHAT WENT WRONG?

Before outlining a solution to the aircrew scheduling problem, it is important to review the failures associated with the effort which began in 1979 for two reasons. The first is to avoid revisiting the mistakes of the past; the second, to refute the notion that further attempts to automate the scheduling process are too costly.[1]

The Wrong Problem

One of the major deficiencies of the current effort was the failure to identify and articulate improved training effectiveness and resource utilization as the primary goal of the project. As noted previously, the training of B-52 aircrews to the minimum requirements of the command has been less than satisfactory. But the document which was to guide the development of the project, the functional description (FD), only addressed the difficulties of the scheduler's task and that the proposed system would make life easier. Quoted below is the complete description of deficiencies of the current manual system and the improvements which were to be gained from the new system.

2.3.e Deficiencies:[2]

(1) Time Delays. The scheduling process is very time consuming, requiring the services of about two full time schedulers per flying squadron in SAC. Adding to the task is the fact that flying schedulers must be highly responsive to outside influences, such as aircraft aborts, weather, aircrew illness, etc. Such

outside influences commonly require the scheduler to rebuild the schedule completely to accommodate a small change. Small changes often have the effect of rippling through a schedule, causing massive numbers of other changes. Adding to the scheduler's task is the fact that he/she must produce weekly, monthly, quarterly, and in some cases semi-annual or annual schedules, called training plans. The current system is often not able to respond to the immediate needs of wings, when outside influences necessitate changes in the schedule.

(2) Administrative Workload. Whenever a small change causes other changes in a schedule, a large amount of paperwork is involved. New schedules must be typed, reproduced and distributed. New flight orders must be typed and signed.

2.4.1 Summary of Improvements[3]

a. Functional Improvements: Scheduling functions would consist of initial input into the system, updating, changing, deleting, extracting formatted data in the quantity desired for distribution. Schedulers would no longer have to build schedules, their only function in that respect would be to keep the data base updated with current data, and monitor the system for malfunctions or possible errors. However, the human element of the decision-making process must remain intact to permit deviation/unscheduled occurrences when or should they arise.

b. Better Balancing: This system will have the capabilities to instantly produce the units flying hour consumption versus the allocation. This data would be accurate to the day and time of the last mission flown for a given day or the current quarter at the time of request. Units will also have the capability of reviewing flying hour accomplishments for the entire fiscal year on a moment's notice. Schedulers would no longer need computer products from the Operations System Management (OSM) Branch. They need only query the system for individual crew training events accomplished/remaining; qualification checks, physicals, etc. The CRT device will permit review of the data on screen and provide a copy of the displayed data if desired.

c. Timeliness: The present scheduling method requires 10 duty days to construct a monthly flying schedule. The inception of the new system would reduce the building process to a matter of hours. Compiling data is also time consuming. The scheduler must compile, then

sort the various media of data received prior to performing the functions of scheduling. However, more time savings will be made under the new system by allowing the scheduler to input and store data on file as it is received or at his/her leisure. Once all the required taskings are on file, the scheduler merely initiates an "Initial Schedule Build" statement. This statement tells the system to activate the SACARMS data base and compiled taskings already stored on file. The interactions of these activities will create a reliable and accurate schedule with all the available current information.

d. The CRT device and schedules stored on disk will eventually eliminate the need for the "grease board" currently found in the 55 SRW scheduling shop.

Note that the deficiencies of the current system and the improvements to be gained by the automated system are administrative and time oriented. This is in direct contrast to the Rand approach, which concentrated ". . . on payoff in terms of training effectiveness, sorties, and resource use, not on making the scheduler's life easier."[4]

The Wrong Prototype

DAR A80-04 called for a prototype system to be developed for the EC-135 operation of the 55 Strategic Reconnaissance Wing (SRW) collocated with HQ SAC on Offutt AFB. Later, before the functional description was finalized, the prototype was shifted to the E-4A operations of the 1st Airborne Command Control Squadron (1 ACCS). Neither of these units are typical of other SAC units, with the E-4A perhaps the most atypical unit of all.

As discussed in the preceding chapter, SAC B-52 units have the greatest difficulty in meeting training requirements, thus to have significant payoff, B-52 units

should be prototyped--not a unit or aircraft which has little problem achieving its requirements.

The seeming expedience of using an on-base unit, merely because it was close at hand, could only guarantee that automation was being applied to an area which did not really need help--nor could a solution to that unit's problem necessarily be applied command-wide.

Lack of Scheduling Experience

Perhaps the single greatest failure evident in the project definition phase was the lack of involvement of individuals with scheduling experience and expertise. As a result, the functional description described a scheduling process and set of decisions which may have appeared logical, but which reflected neither reality nor SAC policy. The FD was a reflection of the aircrew scheduling process as seen by a crew member who is familiar with only the final steps of schedule development. For example, in describing the existing methods and procedures, the FD states:[5]

> 2.3.a There is no standard Air Force means of scheduling aircrews or individuals. Each MAJCOM has a unique training management system that aids scheduling. However, most MAJCOMs use a general scheduling system that involves a cycle of:
>
> (1) Fly the sortie.
>
> (2) Log the training accomplished.
>
> (3) Input the data into a computer.
>
> (4) Computer compares the accomplishments versus requirements to obtain training remaining.

(5) Schedule next sortie based largely on training remaining.

(6) Mission plan the sortie.

(7) Fly the next sortie, etc.

While this appears to be a quite reasonable scheduling process, it is quite wrong. The most critical phase in building a schedule is in the planning phase, where a quarterly schedule is developed. The scheduler begins several weeks before the start of a training period (a three month quarter in SAC) and lays out all known taskings such as alert, leave, TDY, HHD, training requirements, etc. Concurrently, after discussion with squadron operations personnel and other wing level staff agencies, a set of mission profiles is developed which satisfies unit emphasis on such items as night training, low level diversity, etc. These mission profiles are then coordinated with maintenance aircraft schedulers to assure that takeoff and landing times, sortie durations, sorties per week, etc., can be supported. Refinements, compromises and adjustments are made so that the aircraft flow and sortie flow are in concert. Only then is the scheduler prepared to assign sorties to crews. The resultant quarterly plan is then refined on a monthly basis for production of the monthly operations plans.

Finally, during the execution phase of the plan, adjustments are made on a weekly and daily basis. Most training requirements are actually given secondary

consideration at this point, with crew member substitutions, maintenance and weather impacts taking priority. Virtually the only training requirements which are considered in this execution phase are currency or readiness items which would prevent a crew member from assuming alert.

It is the attention to the quarterly plan that spells the success or failure of the schedule (in terms of effectiveness), not daily or weekly scheduling. Consider the guidance published in SACR 60-9, Planning and Scheduling Aircrew and Aircraft Usage:

> The quarterly plan is the key to a good unit schedule. . . . Operations and maintenance schedulers must recognize the importance of quarterly planning to ensure the framework for an effective monthly plan and weekly schedule is started during the development of the quarterly plan. The quarterly plan begins when the unit receives the Flying Program Document (FPD). This document will arrive at the unit seven weeks before the quarter.[6]

Critical to the discussion above is that an algorithm based on the fly-schedule-fly concept is not the same as one based on quarterly planning. Hence the algorithm and computer program(s) developed thereupon will not support the scheduling process as it is practiced and directed.

The treatment of ground scheduling with the same priority and attention as flight scheduling is another example where the FD is at odds with scheduling realities. While these items are essential, in reality, they are relatively easy to schedule, with the majority of ground training conducted while crew members are on alert.

Failure to Address Existing Capabilities

Despite the shortcomings of the document, the FD did insist that any system must interface with the existing automated support systems--the SAC Aircrew Resource Management System (SACARMS), and, later, AFORMS.[7] These systems are essentially bookkeeping systems which track crew member training requirements and accomplishments. They provide a great deal of the historical information on which scheduling decisions are based.

Yet programmers charged with developing the aircrew scheduling system simply failed to learn and understand these systems and the data bases which supported them. As a result, the only software ever produced by the AD community in support of automated aircrew scheduling was a rather limited data base update capability which, when presented in May 1983, was quickly rejected since it could not even closely approach the capability of AFORMS which had been fully implemented at Offutt two months previously.[8]

Project Management

Throughout the numerous letters, memoranda, trip reports and staff summary sheets reviewed, two common threads appear--interagency bickering and a lack of accountability, responsibility and authority.

Interagency Bickering

Within only a few days of the chief of staff's approval of the project, a rift developed between the AD and

DO community, initiated by a DO request to include computer programmers within the 55SRW Provisional Scheduling Section[9]. After a three month exchange of letters, the issue was eventually dropped. But manning was only one of several issues.

The two communities consistently infringed upon the other's perceived functional area of responsibility. Thus AD took umbrage whenever the DO community developed specific architectural requirements such as mass storage and memory size and other hardware requirements.[10] On the other hand, the AD community continually attempted to roll all DO automation requests under a single umbrella project.[11] These attempts were seen by DO as delaying tactics to avoid not only the scheduling project, but several other short term initiatives, which although they may have addressed certain aspects of aircrew training, such as flight planning, were not directly related to the project at hand.[12]

On reflection, much of this bickering seems to have resulted from a lack of analytical expertise in either camp. Analysis, as used here, refers to the rather specific, technical function of translating the human scheduling and decision-making processes into a set of algorithms from which a programmer can then generate the computer code to replicate these processes. This field, often called operations research or operations analysis, requires actual technical expertise and training, not just the appendage of

the word "analyst" to a duty title. Without someone fulfilling this function, the gap between operational requirements and the computer programs to support them could not be bridged.

Accountability, Responsibility and Authority

From both personal observation and a review of the literature, it was fairly obvious that no one individual or agency was ever assigned real responsibility for the successful conclusion of the project. Although project officers were assigned by both AD and DO, they were neither dedicated to the aircrew scheduling project nor were they held accountable for success, failure or progress. The colonel level steering group met only once or twice in the early stages, while working groups were sporadically formed for a short spurt of activity before quickly fading away.

As with responsibility and accountability, authority was never entrusted to a single individual or agency. As a result numerous impasses were never resolved, with each agency doing what they saw fit.

Post Mortem

The automated aircrew scheduling project has made little progress since its inception in 1979. The project did not fail because it was too complex or difficult, nor because of any single agency or individual, but rather due to a combination of several items which fell into two categories, project management and project execution.

Project management was characterized by a failure to establish clear cut authority, responsibility and accountability. As a result, interagency bickering was rampant. The necessary manpower was diluted amongst unrelated projects, appropriate scheduling and analytical expertise was not provided and project definition was never satisfactorily completed.

Project execution, the technical portion of the project, was hampered by the failure to understand and define the scheduling process. This led to the development of a functional description of an overly complicated solution to the wrong problem for the wrong reason. A lack of analytical expertise failed to produce workable algorithms, while a lack of knowledge of existing capabilities and systems led to unnecessary duplication of data base design.

CHAPTER IV

SOME BASIC GUIDELINES

This chapter suggests some basic guidelines for the future development of any automated aircrew scheduling system. Derived from the lessons of the past, they are neither all-inclusive nor are they revolutionary.

Project Management

Program Director

Establish the Director of Training (DOT) as the program director. The responsibility for developing and managing aircrew training programs, scheduling policy, low level training routes, the SAC flying hour program and AFORMS all resides with the DOT. It is DOT needs and requirements which are to be satisfied. Implicit in the acceptance of responsibility is the authority to resolve conflicts and impasses when they develop. General officer involvement should not be required for conflict resolution, but, if so, the final arbiter must be the Deputy Chief of Staff, Operations (DO).

Responsibilities

DOT responsibilities include the definition of requirements which the system must satisfy, the development of appropriate algorithms, provision of functional area expertise, and test and evaluation of any software. Information Systems (SI) responsibilities are to provide

hardware, develop software and to assist in developing appropriate algorithms.[1]

Development of algorithms is seen as a DOT responsibility since they must reflect scheduling processes and policies, not those of data automation.

Organization

Within DOT, program management should be assigned to the training division (DOTT) since that division is responsible for aircrew training, scheduling policy and unit level DO organization. The operations systems management division (DOTF) must be closely involved due to its functional responsibility for AFORMS. A separate DO organization outside of DOT should not be established.

Within SI, primary responsibility rests with the support programming division (SIUS). This division has responsibility for developing SAC unique enhancements to AFORMS, and had previously developed SACARMS and the SACARMS to AFORMS conversion program.

Manning

DOT manpower assigned to this project should include, as a minimum, one officer with extensive B-52 scheduling experience and expertise; one officer or civilian with an operations analysis background; and one NCO with extensive AFORMS experience. These individuals must be dedicated to the aircrew scheduling project from the definition through validation phases. Key is the selection of the

scheduling officer, who must be selected based on scheduling expertise, not for computer literacy or "promotability."

SIU manpower must include programmers conversant with the AFORMS data base, the base level computer system and microcomputers. Microcomputer expertise is required since all SAC scheduling offices have microcomputers which function as AFORMS terminals into the base level mainframe.

Progress Evaluation

DOT must establish a set of appropriate milestones for measuring progress. Milestones should be established on a fairly aggressive schedule in order to avoid diminution of resources and effort. Project reviews, chaired by the DOT, should be conducted at each major milestone, but not less than quarterly.

Test and Evaluation

Field evaluation by unit schedulers is critical since they, not HQ SAC, are the users of the system. This does not alleviate SAC/DOT responsibility for rigorously testing all software prior to field trials.

Development Guidelines

Concentrate on Effectiveness

During the critical definition phase, concentration must remain focused on increasing training effectiveness, not on making the scheduler's task easier. Conversely, automation should not make the task more difficult. Big payoff items should be addressed first, specifically the

ability to generate and evaluate schedules early in the quarterly planning process. Avoid the tendency to automate processes which provide only marginal improvements simply because they are easy to do and give an impression of progress.

Focus on B-52 Scheduling

Since B-52 training rates clearly have the greatest potential for improvement, they also have the greatest payoff potential. Algorithms can become unwieldy or exceedingly complex when attempting to satisfy everyone. When this occurs, solve the B-52 problem first.

Interface AFORMS Early

A great deal of the historical and bookkeeping information necessary for effective scheduling is contained in the AFORMS system. A terminal resides in every scheduling office and tactical squadron. Duplicate data bases, and more specifically, duplicate data entry, should not be tolerated.

Use Existing Hardware

The system should be designed to use the hardware already in place. Specifically, the Sperry 1100 base level mainframe system and the Sperry PC microcomputer. These systems have only recently been fielded by the Air Force and will be around for some time. Attempts to purchase additional or separate systems, such as minicomputers, will only cause endless delays in actually fielding a useful product,

as well as distracting project personnel from the primary task at hand.

Build Tools

A computer program is nothing more than a tool. Some tools, such as word processing programs, are extremely useful when dealing with textual data, but are of little utility in an accounting role--for which other tools have been developed. This same concept applies to aircrew scheduling. One tool may be useful for generating a quarterly plan, another for evaluation of that plan, and yet another for weekly scheduling. Thus, rather than attempting to design and build one all-encompassing system, build a set of tools, each designed for a specific task.

Perfection is Not a Requirement

A scheduling tool does not have to perform an entire task in order to be valuable. A schedule generation program, for example, which only generates a flying schedule, but not a ground training schedule it still useful, despite the fact that ground training items are not scheduled automatically. Systems should be designed and evaluated not on how much of the task they can perform, but rather on how they improve training and scheduling effectiveness.

CHAPTER V

THE SCHEDULING ASSISTANCE SYSTEM

The primary purpose of this research effort has been the development of the Scheduling Assistance System (SAS) as a feasibility demonstration model for future development. SAS comprises a set of several computer programs which are designed to provide Strategic Air Command aircrew schedulers with a set of tools to help build and evaluate aircrew training plans early in a training period and subsequently make the necessary mission and training adjustments early, thereby contributing to schedule stability as well as consistently high training rates.

Background

Historically, SAS evolved from a precursor system called DOTARMS (DOT Aircrew Resource Management System), which was developed by the author while serving as the Director of Training at the 92nd Bomb Wing, Fairchild AFB, WA. The initial system was designed to evaluate the effectiveness of a manually produced aircrew training schedule and to identify potential training shortfalls. An initial set of programs was developed, using solely in-house computer programming capability, which verified the concept.

That initial program set has been expanded and revised considerably. AFORMS ID numbers and codes have been incorporated rather than the codes used in the now obsolete

SACARMS system. The initial sequential file access routines have been replaced with substantially faster direct access routines. A menu-driven front end has been added which directs execution of all other programs, as well as loading numerous common constants which assists in speeding up operation. In addition, the entire system has been "universalized" to accept most SAC aircraft. That system is now known as the Scheduling Assistance System, with the current version (SAS 2.0) having been developed while the author attended the Air War College.

While SAS 2.0 provides a useful set of scheduling assistance tools, a capability to automatically generate a schedule was still lacking. Based on conversations with several unit schedulers, it became obvious that satisfying the entire requirement established in the Crew Scheduling System Functional Description was not only unnecessary and unwarranted, but would, in fact, actually hinder the scheduling process as schedulers would become hamstrung by the overwhelming data input requirements of such a system. What was really needed was a capability to quickly generate a fairly good "first cut" quarterly schedule which would take into account crew availability, sortie requirements and diversification, outputting various statistics as well as a schedule. Evaluation of the resultant schedule could then be accomplished with the existing software. Fine tuning of the schedule was felt to be better left to human insight.

Based on this idea, an algorithm was derived and a workable, albeit limited, capability was developed which validated the algorithm and which indicated that, in fact, a quite useful scheduler could be developed quickly, inexpensively and on even the smallest microcomputer system. While attending the Air War College, the author pursued the concept and developed the automated scheduler as SAS 3.0, an extension to the redesigned SAS 2.0.

The Concept

The main concept underlying the SAS 3.0 automated scheduling system is that an effective aircrew training program begins with a well conceived quarterly training plan. That training plan, or quarterly schedule, should provide aircrews with a diversification of training (reflected by a decent sortie mix) which meets both command and wing directed training requirements. Experience has shown that up to two weeks of concentrated effort by unit schedulers is required to develop even a "first cut" training plan, which must then be modified or fine tuned as the quarter approaches. This training plan, especially in the case of the B-52 force, must be developed in an atmosphere of limited sortie production, thus making critical the distribution of aircrews and sorties, since there are few additional sorties available with which to improve training diversity. Historically, the B-52 force has suffered from just such a maldistribution of sortie and event activity.

Units which fail to adequately prepare a quarterly training plan end up scrambling throughout the execution quarter, "chasing" training requirements, and achieving low training rates. Hence the SAS 3.0 automated scheduler has been designed with the SAC bomber requirement in mind, although the concept can be extended to the KC-135 scheduling problem.

In the case of the bomber force, sorties are fairly well tied to the availability of low level strategic training routes (STRs), which are "bought" on a quarterly basis through the STR scheduling and allocation process. Of particular note is the fact that STR routes are allocated for the same time and same day each week, throughout the entire quarter.

Mission packages are then designed around the low levels which include, hopefully, sufficient night, fighter, cell formation, navigation, etc. activity, such that, given a decent distribution of missions, each crew will have sufficient opportunity to meet their training requirements. Thus a standard week of sorties is created. It is this regularity which SAS 3.0 uses as a basis for its quarterly schedule generation.

What SAS Does

SAS 3.0 automatically generates a quarterly schedule of missions for the flying wing, distributing the various sorties among the aircrews. The schedule which is produced

is a "first cut" schedule, which, in all probability, still requires some fine tuning. However, the actual process of creating that schedule is reduced from two weeks to a matter of minutes. The fine tuning process is minimal, accomplished within a few hours at most.

Obviously several inputs to the program are necessary. These consist of an alert, CCRR, and leave schedule; a "MASTER WEEK" of sorties; the crew sortie requirement for the quarter; and any known "hard" requirements, such as higher headquarters directed (HHD) missions or crew TDYs. With the exception of the MASTER WEEK, such information is obtained from the files created using SAS 2.Ø. The program which generates the MASTER WEEK file, is included in the SAS 3.Ø package.

Priority

SAS 3.Ø schedules crews against sorties on a priority to fly basis, thus crews which may be unavailable at the end of the quarter due to leave, for example, are scheduled at a higher priority than other crews. Similarly, crews with minimum availability throughout the quarter (higher alert, TDY commitments) are likewise provided higher priority. Currently, priority to fly is computed on the number of sorties required by the crew divided by the number of days available remaining in the quarter.

Diversification

SAS 3.0 attempts to maximize sortie diversification based on the mission identification (ID) number of the sortie, the low level route, a sortie option, day/night, and up to sixteen user defined parameters. Options are provided to disregard this built-in diversification. Specifically, each mission in the MASTER WEEK is coded with a three character mission ID. The first character is an 'F' or 'f', which designates the activity as a flying mission. The second character is used to indicate the low level route for that sortie. (In actuality, this second character may represent anything, such as air refueling routes or type receiver for tanker units.) The third character (optional) is the sortie option, which can be used to differentiate between different sorties which may use the same low level route. Thus option "A" could indicate day, and option "N" night. For example, the mission ID "F3A" could identify a day sortie with day air refueling and a cell navigation leg, whereas "F3B" identifies basically the same sortie, but has a fighter intercept exercise added on.

Night diversification is achieved by identifying the sortie as a "late lander" during construction of the MASTER WEEK file.

Up to sixteen sortie parameters may be identified by the user which can be used to further diversify the aircrew training. Of special note, these parameters provide an easy

way of diversifying such items as fighter activity, cell formation, MITO, high bombing, etc. SAS 3.0 is oblivious to what the parameters specifically mean, but it does attempt to diversify sorties among crews based on these parameters, and, of particular use to the scheduler, provides a listing of the diversification of these parameters at the completion of its schedule generation.

Diversification is achieved by examining the MASTER WEEK and computing the ratio of different mission IDs, low level routes, sortie options, night, and each parameter to the total availability of such items in the MASTER WEEK. This ratio is then applied against each crew's sortie requirement and an "ideal" number of each item is computed for that crew. If this "ideal" number is exceeded in any category, the crew will not be scheduled for a particular sortie, except when it is the only crew available which could fly the particular sortie (even this feature can be turned off and the sortie left unfilled).

Scheduling Rules

When building a schedule, SAS 3.0 adheres to certain common rules and desires of the operations and training community. Specifically, SAS 3.0 will not schedule a crew for the same mission twice in a row, or even the same low level route twice in a row, except as a last resort (i.e., the only crew available). SAS 3.0 will not schedule a crew to exceed its "ideal" diversification as described above,

except as a last resort. Crews, scheduled for alert, TDY or leave the following day, will not be scheduled for sorties which land later than the unit's locally determined landing time for such cases. Crews will not be scheduled following CCRR for sorties which take off prior to the unit's local time for this situation. Crews will not be scheduled unless the day preceding is available for mission planning. SAS 3.0 will, however, allow holidays, weekends, and CCRR to come between the designated mission planning day and the day of the mission. In the case of CCRR, the last day of alert will be designated as the mission planning day. Even when sorties are identified as being capable of being mission planned and flown on the same day, SAS 3.0 will only schedule a crew to mission plan/fly the same day if no preceding mission planning day is available and no other crew is available.

The "last resort" feature refers to the fact that sometimes one of the desires or rules above may have to be violated in order to fill a sortie. In terms of SAS 3.0, this is referred to as AUTOFILL, i.e., a crew will not be scheduled to fly a sortie if it violates any of these rules, unless no other crew can be found to fly the sortie which itself does not violate one or more of the rules. This AUTOFILL feature, normally ON, can be turned OFF and the sortie left unfilled. In addition, each of the rules above can be suspended.

What SAS Does Not Do

While the Scheduling Assistance System does provide the unit aircrew scheduler with a variety of tools to enhance the scheduling process, it is not a panacea. SAS will not and can not reduce manpower, its purpose is to enhance the effectiveness of the scheduling process by automating certain manual, time consuming, repetitive functions.

SAS 3.0 only schedules entire aircrews, not individual aircrew members, hence such important items as flight physicals and ground training requirements still require manual scheduling. In the same vein, crews with missing crew members are treated as if they were complete crews, substitution for non-mission ready or absent crew members also requires manual scheduling. (Incidentally, AFORMS does have some capability to identify the availability of individual crew members.)

SAS 3.0 does not schedule alert, CCRR, leave, or any ground requirements (other than mission planning). All such activity must be manually scheduled. In actual practice the quarterly, and even annual, scheduling of alert, CCRR and leave does not appear to be a major problem at the crew level. Individual substitutions for alert and leave is another issue.

As currently programmed, SAS 3.0 generates only a full three month quarterly schedule. It is not capable of rescheduling the remainder of the quarter from some point

later on in the quarter. This capability could be added with minimal reprogramming.

SAS 3.0 is geared to scheduling sorties based on a MASTER WEEK. While this makes a great deal of sense in the bomber world, many tanker sorties are not necessarily tasked on a weekly basis. Although not explored in detail, it appears that SAS 3.0 could be modified relatively easily to handle a quarterly sortie flow as input, rather than just a weekly flow.

SAS 3.0 will not develop mission profiles. The scheduler or mission developer must build the actual mission packages themselves. The SAS 2.0 system will, however, evaluate the training shortfalls of a schedule built on those sorties. Thus the scheduler is provided with a hard-copy product from which changes to mission profiles can be made to ensure that sufficient opportunity exists in which to complete the training requirements.

As of now, the user is required to use SAS 2.0 to develop the data bases required of the SAS 3.0 automated scheduling function. Similarly, once a schedule has been created, it can only be printed and evaluated by returning to SAS 2.0. This inconvenience is simply due to the time available to the author to reprogram the entire SAS 2.0 program set.

Perhaps the major deficiency of both SAS program sets is in its standalone nature, without interface to

AFORMS. While this is easily remedied and well within the capabilities of HQ SAC, it does require a commitment of HQ SAC/SI computer programmer resources and HQ SAC/DO functional area cooperation and design analysis. As it now stands, SAS has to maintain several data files which only duplicate files which exist in AFORMS, as a result needless data input duplication is required.

Hardware and Software Requirements

Both SAS systems (2.0 and 3.0) have been designed to operate under the CP/M operating system with a minimum of 64K memory, a printer and two disc drives. An MS-DOS version is under development.

While the bulk of the SAS program set (version 2.0) was programmed in CBASIC, the automated scheduler programs (SAS 3.0) were written in 'C', due to its greater efficiency and reduced memory requirement. A file conversion program is provided to maintain compatability between the two versions. Eventually, it is the author's intent to convert the SAS 2.0 programs to 'C' and the SAS 3.0 file structure.

CP/M is a registered trademark of Digital Research Corp.

MS is a trademark of Microsoft Corporation.

CBASIC is a trademark of Compiler Systems, Inc.

CHAPTER VI

CONCLUSIONS

The combat capability of Strategic Air Command aircrews is to a large extent determined by the quality of their training, which is directly controlled by the aircrew scheduling process. The major component of SAC's combat power, the B-52 force, suffers from relatively low training rates. While several diverse factors contribute to this state, they all come together during the development of the flying schedule. Subsequently, improvements in the aircrew scheduling process should translate directly to improved training and combat readiness.

Due to the complexities of the scheduling process and the enormous number of individual data elements which must be managed and analyzed, automated support is mandated. Existing computer systems, such as AFORMS, perform essential bookkeeping functions, but are not designed nor capable of producing or evaluating the effectiveness of aircrew training schedules.

A major SAC effort, intitiated in 1979, to apply automation to the schedule generation and evaluation functions has been unsuccessful to date. The effort did not fail because it was too difficult or too expensive. The project failed for such rather simple reasons as failing to involve experienced schedulers in the definition and design

phases, failing to identify the problem, and failing to assign responsibility, accountability and authority for management of the project.

Automated schedule generation and evaluation is quite feasible and relatively inexpensive. This has been demonstrated by the development of the Scheduling Assistance System. This set of automated tools allows a scheduler to rapidly generate aircrew training plans, evaluate them, and make necessary sortie and training adjustments early in the schedule development cycle. This facilitates more effective training and increased schedule stability.

Using the scheduling and programming concepts of the Scheduling Assistance System as a model, a comprehensive, integrated, inexpensive package of automated scheduling tools can be developed and fielded command-wide in relatively short order. The payoff in terms of training effectiveness and combat capability warrant the pursuit of such an effort within the Strategic Air Command.

NOTES

CHAPTER I (Pages 1-2)

1. Morton B. Berman, Improving SAC Aircrew and Aircraft Scheduling to Increase Resource Effectiveness, Rand Report R-1435-PR (Santa Monica: Rand Corporation, July 1974), p. 79.

2. Report of Visit, HQ SAC/ADO, Offutt Air Force Base, Nebraska, subject: Visit to American Airlines Office, Tulsa, Oklahoma, 17 December 1979.

Report of Visit, HQ SAC/DOTF, Offutt Air Force Base, Nebraska, subject: Visit to American Airlines, Chicago, Illinois, 23 January 1980.

3. "EC-135 Feasibility Study--Scheduling," Data Automation Requirement SAC A80-04, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 11 January 1980.

4. Staff Summary Sheet, Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: SAC Operations System, 21 March 1980.

Point Paper, HQ SAC/DOTF, Offutt Air Force Base, Nebraska, subject: SAC Operations System, 10 March 1980.

5. Letter, Deputy Chief of Staff, Operations to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Operations Automation Initiatives, 1 December 1981.

Letter, Deputy Chief of Staff, Operations to Deputy Chief of Staff, Data Service, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Operations Automation Initiatives, 24 December 1981.

6. Memo for Record, HQ SAC/ADOFMO, Offutt Air Force Base, Nebraska, subject: Meeting with DOTF Concerning Aircrew Scheduling, 30 July 1981.

Letter, Deputy Chief of Staff, Data Services to Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Operations Automation Initiatives, 7 December 1981.

Background Paper, HQ SAC/ADOFMO, Offutt Air Force Base, Nebraska, subject: Current SAC/DO Automation Events, undated (circa December 1981).

CHAPTER II (Pages 3-7)

1. Operations and Training Divisions--Functions, Strategic Air Command Regulation 55-65 (Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 24 September 1980), p. 2-1 (paragraphs 2-1, 2-2 and 2-3).

2. Numerous Aircrew Training Reports were produced by the Training Management Information Branch, HQ SAC/DOTFT. The first such report, limited to the B-52, covered aircrew training data for the second fiscal quarter of 1984. Subsequent reports were produced, quarterly, for the B-52, KC-135, FB-111 and KC-10 aircraft. The last such report covered the second fiscal quarter of 1985. Computer difficulties and management problems have prevented production of subsequent reports. Rather than list every volume produced, the following entry is representative of each report:

B-52 Aircrew Training Report, FY 2/85, (Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command), pp. 5-6.

3. Berman, op. cit., p. 22.

4. U S Air Force Cost and Planning Factors, Air Force Regulation 173-13, (Washington, D.C.: Department of the Air Force, 1 February 1985), p.6 (table 2-1).

5. Berman, op. cit., p. x.

6. B-52 Aircrew Training: Continuation Training (Phase III), Strategic Air Command Regulation 51-52, 7 vols. (Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 24 March 1984), 4:6-1 to 6-7, 7-1 to 7-3.

7. Morton B. Berman, Scheduling Aircrews and Aircraft: Problems of Resource Allocations in the Strategic Air Command, Rand Report R-1610-PR (Santa Monica: Rand Corporation, January 1975), p. 90.

CHAPTER III (Pages 8-17)

1. Letter, Deputy Chief of Staff, Data Services to Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Status Update on Air Crew Scheduling Project, 15 August 1983.

Mitre Corporation, "Aircrew Scheduling System Review," briefing presented to Data Services and Operations personnel, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 30 June 1983.

2. Crew Scheduling System Functional Description (Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 1 March 1982), p. 2-2.

3. Ibid., pp. 2-4 to 2-7.

4. Richard J. Hillestad, Review of the DOSS Research: A Briefing, Rand Working Note WN-9771-AF (Santa Monica: Rand Corporation, April 1977), p. 18.

5. Crew Scheduling System Function Description, op. cit., pp. 2-1, 2-2.

6. Planning and Scheduling Aircrew and Aircraft Use, Strategic Air Command Regulation 60-9 (Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 22 August 1984), p. 4-3.

7. Crew Scheduling System Function Description, op. cit., pp. 2-1.

8. Point Paper, HQ SAC/ADUP, Offutt Air Force Base, Nebraska, subject: Air Crew Scheduling (ACS) Status, 10 May 1983.

Letter, HQ SAC/ADUP to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Automated Aircrew Concept Paper, 22 September 1983.

Letter, Deputy Chief of Staff, Operations to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Automated Aircrew Scheduling Program, 14 October 1983.

Letter, HQ SAC/ADUP to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Aircrew Scheduling Update, 20 October 1983.

Point paper, HQ SAC/ADUPS, Offutt Air Force Base, Nebraska, subject: Aircrew Scheduling Project, 20 October 1983.

9. Letter, Director of Training, to Director of Manpower, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Manpower Authorization Change Request, 31 March 1980.

Memo, Director of Computer Applications to Director of Training, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: Non-concurrence with Manpower Change Request, 10 April 1980.

Letter, Director of Training to Director of Computer Applications, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: 55SRW Provisional Scheduling Section, 13 May 1980.

Letter, Director of Computer Applications to Director of Training, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, subject: 55SRW Provisional Scheduling Section, 9 June 1980.

10. Letter, HQ SAC/DOTF to HQ SAC/ADOF, Offutt Air Force Base, Nebraska, subject: Non-concurrence with Draft Crew Scheduling Functional Description, 10 March 1981.

Memo for Record, subject: DOTF Reply to Crew Scheduling Functional Description, HQ SAC/ADOF, Offutt Air Force Base, Nebraska, undated (circa March 1981).

11. "Potential Consolidation of SAC/DO Automation Requirements," concept paper, HQ SAC/ADOF, Offutt Air Force Base, Nebraska, 29 September 1981.

12. Letter, Commander 28th Bombardment Wing (Heavy), Ellsworth Air Force Base, South Dakota to Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, subject: Data Automation Request for Mission Development Data Management System, 20 July 1981.

13. "Justification for a North Star Horizon Small Computer for 1st Airborne Command Control Squadron (1ACCS)," Data Automation Requirement SAC A81-167, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, undated (circa September 1981).

CHAPTER IV (Pages 18-22)

1. During 1984 SAC established a new deputate, the Deputy Chief of Staff, Information Services (SI) which combined two previous deputates, Communications and Data Services (AD). In general, an office previously identified as ADUP became known as SIUP under this latest reorganization.

BIBLIOGRAPHY

Air Crew Scheduling (ACS) Status. Point Paper, HQ SAC/ADUP, Offutt Air Force Base, Nebraska, 10 May 1983.

Aircrew Scheduling Project. Point paper, HQ SAC/ADUPS, Offutt Air Force Base, Nebraska, 20 October 1983.

"Aircrew Scheduling System Review." Mitre Corporation briefing. Offutt Air Force Base, Nebraska, 30 June 1983.

Air Crew Scheduling System/Subsystem Specification. Offutt Air Force Base, Nebraska: Strategic Air Command, 19 May 1982.

Aircrew Scheduling Update. Letter, HQ SAC/ADUP to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 20 October 1983.

"Air Force Operations Resource Management System." Data Automation Requirement HAF-A76-18. Washington, D.C: Department of the Air Force, 1 November 1976.

Air Force Operations Resource Management System (AFORMS) Functional Description. Air Force Manual 171-190, Volume IV. Washington, D.C.: Department of the Air Force, 29 April 1983.

Automated Aircrew Concept Paper. Letter, HQ SAC/ADUP to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 22 September 1983.

Automated Aircrew Scheduling Program. Letter, Deputy Chief of Staff, Operations to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 14 October 1983.

B-52 Aircrew Training: Continuation Training (Phase III). Strategic Air Command Regulation 51-52, 7 vols. Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 24 March 1984.

B-52 Aircrew Training Report, FY 2/85. Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command.

Berman, Morton B. Improving SAC Aircrew and Aircraft Scheduling to Increase Resource Effectiveness. Rand Report R-1435-PR. Santa Monica: Rand Corporation, July 1974.

________. Scheduling Aircrews and Aircraft: Problems of Resource Allocations in the Strategic Air Command. Rand Report R-1610-PR. Santa Monica: Rand Corporation, January 1975.

Computer Support for Operations Scheduling. Letter, Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command to Commander, 55th Strategic Reconnaissance Wing, Offutt Air Force Base, Nebraska, 21 January 1980.

Crew Scheduling System Functional Description. Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 1 March 1982.

Current EC-135 Scheduling Procedures. Letter, 55 SRW/DOTT to HQ SAC/DOTF, Offutt Air Force Base, Nebraska, 5 May 1980.

Current SAC/DO Automation Events. Background Paper, HQ SAC/ADOFMO, Offutt Air Force Base, Nebraska, undated (circa December 1981).

Data Automation Request for Mission Development Data Management System. Letter, Commander 28th Bombardment Wing (Heavy), Ellsworth Air Force Base, South Dakota to Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, 20 July 1981.

DOTF Reply to Crew Scheduling Functional Description. Memo for Record, HQ SAC/ADOF, Offutt Air Force Base, Nebraska, undated (circa March 1981).

"EC-135 Feasibility Study--Scheduling." Data Automation Requirement SAC A80-04. Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 11 January 1980.

Fallon, Richard. DOSS as an Analysis Tool: Applications to the B-52 Aircrew Continuation Training Test Program--A Progress Report. Rand Note N-1161-1-AF. Santa Monica: Rand Corporation, July 1979.

________. Improving Scheduling and Resource Allocation: A Briefing of Work in Progress (Draft). Santa Monica: Rand Corporation, September 1978.

________. Rule-Based Modeling as an Analysis Tool: Implications for Resource Allocation Within the Strategic Air Command. Rand Note N-1489-AF. Santa Monica: Rand Corporation, April 1980.

Hillestad, Richard J. Review of the DOSS Research: A Briefing. Rand Working Note WN-9771-AF. Santa Monica: Rand Corporation, April 1977.

"Justification for a North Star Horizon Small Computer for 1st Airborne Command Control Squadron (1ACCS)." Data Automation Requirement SAC A81-167, Offutt Air Force Base, Nebraska, undated (circa September 1981).

Manpower Authorization Change Request. Letter, Director of Training to Director of Manpower, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 31 March 1980.

Meeting Minutes of the Operations Scheduling System Group. Minutes, HQ SAC/DOTF, Offutt Air Force Base, Nebraska, 10 March 1980.

Meeting with DOTF Concerning Aircrew Scheduling. Memo for Record, HQ SAC/ADOFMO, Offutt Air Force Base, Nebraska, 30 July 1981.

Non-concurrence with Draft Crew Scheduling Functional Description. Letter, HQ SAC/DOTF to HQ SAC/ADOF, Offutt Air Force Base, Nebraska, 10 March 1981.

Non-concurrence with Manpower Change Request. Memo, Director of Computer Applications to Director of Training, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 10 April 1980.

Operations Automation Initiatives. Letter, Deputy Chief of Staff, Operations to Deputy Chief of Staff, Data Services, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 1 December 1981.

________. Letter, Deputy Chief of Staff, Data Services to Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 7 December 1981.

________. Letter, Deputy Chief of Staff, Operations to Deputy Chief of Staff, Data Service, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 24 December 1981.

Operations and Training Divisions--Functions. Strategic Air Command Regulation 55-65. Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 24 September 1980.

Planning and Scheduling Aircrew and Aircraft Usage. Strategic Air Command Regulation 60-9. Offutt Air Force Base, Nebraska: Headquarters, Strategic Air Command, 22 August 1984.

"Potential Consolidation of SAC/DO Automation Requirements." Concept paper, HQ SAC/ADOF, Offutt Air Force Base, Nebraska, 29 September 1981.

SAC Operations System. Staff Summary Sheet, Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 21 March 1980.

________. Point Paper, HQ SAC/DOTF, Offutt Air Force Base, Nebraska, 10 March 1980.

Status Update on Air Crew Scheduling Project. Letter, Deputy Chief of Staff, Data Services to Deputy Chief of Staff, Operations, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 15 August 1983.

U S Air Force Cost and Planning Factors. Air Force Manual 173-13, Volume I. Washington, D.C.: Department of the Air Force, 1 February 1985.

Visit to American Airlines Office, Tulsa, Oklahoma. Report of Visit, HQ SAC/ADO, Offutt Air Force Base, Nebraska, 17 December 1979.

Visit to American Airlines, Chicago, Illinois. Report of Visit, HQ SAC/DOTF, Offutt Air Force Base, Nebraska, 23 January 1980.

55SRW Provisional Scheduling Section. Letter, Director of Training to Director of Computer Applications, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 13 May 1980.

________. Letter, Director of Computer Applications to Director of Training, Headquarters, Strategic Air Command, Offutt Air Force Base, Nebraska, 9 June 1980.

GLOSSARY

ACCS	Airborne Command Control Squadron
AD	Deputy Chief of Staff, Data Services
ADO	Director of Computer Applications
AFB	Air Force Base
AFORMS	Air Force Operations Resource Management System
ALCM	Air Launched Cruise Missile
ATR	Aircrew Training Report
B-52	Strategic bomber aircraft
CCRR	Combat Crew Rest and Recuperation
CDE	Command Directed Event
CRT	Cathode Ray Tube
DAR	Data Automation Requirement
DNIA	Duty Not Involving Alert
DNIF	Duty Not Involving Flying
DO	Deputy Chief of Staff, Operations
DOT	Director of Training
DOTF	Operations Systems Management Division
DOTFT	Training Management Information Branch
DOTT	Training Division
E-4A	A command and control aircraft for use by the National Command Authority. Also known as the National Emergency Airborne Command Post.
EC-135	A command and control aircraft used as an airborne command post for SAC. Also known as the "Looking Glass."
FB-111	A medium range strategic bomber aircraft.

FD	Functional Description.
FPD	Flying Program Document
HHD	Higher Headquarters Directed
HQ	Headquarters
ICR	Individual Completion Rate
ID	Identification
K	Kilobyte
KC-135	Strategic tanker aircraft
MAJCOM	Major Command
MITO	Minimum Interval Take Off
MOP	Monthly Operations Plan
NCO	Noncommissioned Officer
OAS	Offensive Avionics System
OSM	Operations Systems Management
PC	Personal Computer
SAC	Strategic Air Command
SACARMS	SAC Aircrew Resource Management System
SACR	SAC Regulation
SAS	Scheduling Assistance System
SI	Deputy Chief of Staff, Information Systems
SIUS	Support Programming Division
SRW	Strategic Reconnaissance Wing
STR	Strategic Training Route
TDY	Temporary Duty
WDE	Wing Directed Event

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